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Sweet Potato Production for Bio-ethanol and Food Related Industry in Indonesia: Challenges for Sustainability

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Abstract

As an underground crop, tuberous root of sweet potato (*Ipomoea batatas*) is the main economical yield expected from various level of cultivation. Aside rich in carbohydrate, sweet potato root contains vitamin and mineral. The degree of utilization reflects the level of subsistence to commercialization, where the desire or needs can be easily met was defined as prosperity. Supplying continuously the demand of sweet potato for subsistence and commercialization oriented to bio-ethanol and food related industries depend on the sustainable production system. To sustain sweet potato production system, the severe biotic and a-biotic stresses have to be alleviated.

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Keywords: Bio-ethanol; food; sustainability; sweet potato

Nomenclature

CIP	Centro Internacional de la Papa	**mo**	month
TBI	Toyota Bio Indonesia	**yr**	year
BERDC	Bio Energy Research Development	**1 t =**	10^3 kg
wap	week after planting		

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1. Introduction

Bio-ethanol from sweet potato (*Ipomoea batatas*) is widely producing as socu an alcoholic beverage in Japan. The demand of bio-ethanol as renewable fuel in line with ecologically friendly energy, promotes sweet potato to be more important. Unlike cereals and grain legumes that yield is clearly located aboveground, while sweet potato and other root & tuber crops its tuberous root yield is underground. As consequence yield level is recognized after harvest. Digging out the tuberous root is the only way for harvesting; that corollary to the whole part of plant is removed out from the field. Very few of plant part are return back to the soil for maintaining sustainability. Therefore, sustaining sweet potato production system is a huge challenge. According to reference[1] sweet potato, in nature, is a perennial plant (36 mo) due to human domestication it is cultivated as an annual crop (3.5 to 8) mo. In Indonesia, as tropical zone, sweet potato can be planted in many kinds of environment and climate. From Sabang Island in the north of Sumatra till Merauke in the south part of Papua, sweet potato can be easily found as one of food crop planted by farmers. The wide range adaptability of sweet potato under different altitudes, soil types and its fertility levels and relatively requires an inexpensive input, less pest and disease therefore sweet potato is preferred by people for providing their own food consumption; for complementing feed stuff and supplying raw material of industrial enterprise[2,3]

2. Method

To represent the overall description of sweet potato development in Indonesia a historical perspective studies were carried out in collaboration of ILETRI with Centro Internacional de la Papa (CIP) International Potato Centre as well as the other international and regional institutions. In 1988 CIP was started to collaborate with ILETRI, and CIP joined the branch office at Centre Research Institute for Food Crops which now as Indonesian Centre of Food Crops Research and Development (ICFORD) at Bogor. Identification of problems encounteredin sweet potato farming as well as indigenous knowledge related was done in several sites of Indonesia. In the period of 1992 to 1997 the program was focused in tailoring curriculum for Farmer Field School (FFS) on sweet potato. Entering third millennium CIP also support the endeavour of Toyota Motor Company (TMC) at Nagoya to invest on sweet potato production in Lampung, with emphasized on alcoholic beverage (socu) product as well as flake and frozen paste. Publication of this project was disseminated by CIP into several media and reports. Sweet potato industry is in Lampung under TMC with the name of Toyota Bio Indonesia (TBI). To verify the data as chronologically narrative the team of researchers made several visits to the sites domestic and overseas related to the aspect studied. Descriptive analyses from deductive and inductive approaches were adopted to allocate the findings emphasize into two aspects namely sweet potato for bio-ethanol oriented to Japan demand as socu as well as potential for bio fuel; and sweet potato for food as well as food related industries.

3. Result and discussion

3.1. Bio-ethanol beverage and bio fuel

To supply the demand of sweet potato as raw material of socu alcoholic beverage, several factories in North Sumatra, Lampung and West Central till East Java exporting sweet potato frozen paste to Japan. Cultivars planted as raw material of socu raw material is mainly white flesh with high dry matter content. To anticipate the greater demand ILETRI and CIP release new cultivar Sukuh. Unfortunately, after Sukuh was planted widely in large field at Lampung, but the productivity was very low only around (2 to 6) $t \cdot ha^{-1}$. To improve productivity of sweet potato new introduction cultivar from Japan Shiroyutaka was formally released and recommended. However, after 2 yr planted in around Lampung, Shiroyutaka was very susceptible to Fusarium, and as consequence the low yield was obtained. Stem borer and weevil were very serious pest of sweet potato Shiroyutaka in Lampung. Weed is always as serious problem of sweet potato in upland at rainy season as well as in lowland at dry season planted after rice. Therefore to sustain sweet potato production system to supply for raw material of bio-ethanol factory as well as food related products in Lampung need support from other provinces (Table 1). As consequence the cost for transportation will be a new serious problem that induces the price of product do not competitively feasible.

In Sulusuban Lampung the Bio Energy Research Development (BERDC) in early nineteen eighty used sweet potato as one of raw material to be processed as renewable fuel in the form of bio-ethanol. Although from laboratory

level it was very success, however scaling up of sweet potato production into large plantation was really difficult due to biotic and abiotic stresses both in rainy and dry season (Table 2). Therefore, BERDC in the progress of renewable fuel development, especially bio-ethanol is using molasses from sugarcane as well as cassava. Recently, BERDC also develops sweet sorghum (*Sorghum vulgare*) and Arenga palm (*Arenga saccharifera*) as raw material for bio-ethanol. The problem encountered in sweet potato production for bio-ethanol as renewable fuel due mainly to the low productivity, although from research result it was able to attain 30 $t \cdot ha^{-1}$ however in reality at large scale productivity only around (5 to 8) $t\ ha^{-1}$. As consequence an inability to meet the demand is to switch into the more prospective raw materials such as molasses, cassava, sweet sorghum and arenga juice.

Table 1. Potential and challenge of sweet potato development in Indonesia directed for food security and bio-ethanol.

Main island	Potential production ($t \cdot ha^{-1}$)	Actual production ($t \cdot ha^{-1}$)	Current utilization and future prospect
North Sumatra	32	12 to 18	Local consumption and export
South Sumatra and Lampung	28	8 to 16	Local consumption and export as raw material of socu
West, Central and East Java	40	15 to 35	Domestic, inter island and export
Kalimantan	26	8 to 17	Local consumption
Sulawesi	28	11 to 18	Local consumption and export
Bali and Nusa Tenggara	35	12 to 20	Local consumption and export
Maluku and Papua	32	6 to 14	Local consumption

Note: this data based on direct observation by yield cut survey as well as information from farmers during Forum Group Discussion.

It seems the providence of sweet potato production for bio-ethanol as alcoholic beverage (socu) in Lampung by TBI is almost similar to the fate of the project of bio-ethanol as renewable fuel at Sulusuban Lampung by BERDC. Indeed huge endeavours had been undertaken by TBI by developing two systems; namely sweet potato plantation fully managed by TBI and sweet potato managed by farmers with TBI supervision. However, from both schemes under similar agro-ecosystem of acid ultisol soil the productivity of sweet potato is remaining low. Indeed[4] suggested organic and inorganic fertilizer with additional of dolomite to improve soil fertility of acid ultisol soil has to be undertaken to accomplish higher productivity of sweet potato. Based on long experience working with TBI the recommendation of organic manure from animal dunks is a must at least every 2 yr (Table 3). Consecutive planting of sweet potato in ultisol is not recommended, unlike in andisol, entisol as well as inceptisol at high altitude. Consecutive planting of sweet potato at ultisol soil such as in TBI areas will harvest nothing, because early senescence is the most common phenomenon. Early senescence is mostly after sweet potato entering 2 mo old, some of leaves yellow indicating physiological symptom mimics potassium deficiency. *Fusarium* sp. at foliages and nematodes in the roots were detected.

Table 2. A-biotic and biotic stresses as the challenge for sustaining sweetpotato production system.

Problem encountered	Rainy season	Dry season
1. Abiotic stresses		
a. Soil/land	In a form of ridge easy to damage by erosion due to rainfall	Low in soil moisture and organic matter content affect to soil compaction that have a detrimental effect to yield obtained
b. Water	Excessive water promotes to poor yield and tuber rotten	Drought severity promotes to crop wilt and poor nutrient absorption
c. Weather	Cloudy less sun light promotes to vigorous growth of aboveground portions. High relative humidity suitable for outbreak of disease	Hot temperature and windy promote to moisture losses by evapotranspiration process
2. Biotic stresses		
b. Disease	Leaves and vines scab, *Fusarium* wilt, stem and tuber rot, as well as anthracnose need more attention	*Fusarium* wilt as well as stem and tuber rot in the early dry season are also serious

Continued on next page

Table 2. Continued

Problem encountered	Rainy season	Dry season
c. Weed	Severe	Mild

Note: Although in order to maintain continuous supply sweet potato must be grown year round, however it is not recommended to cultivate in consecutively or continuously at the same land; crop rotation with legumes or cereals is suggested to rejuvenate the soil and to discontinue the host of pest and disease.

Table 3. The amount of organic fertilizer required ($t \cdot ha^{-1}$) to maintain soil fertility as basic requirement for sustaining sweet potato production system

Soil organic matter content (%)	Amount of organic fertilizer required ($t \cdot ha^{-1}$)		
	Top soil depth (cm)		
	< 15	15 to 20	> 20
< 1	40	30	20
1 to 2	30	20	10*
> 2	20	10*	5*

Note: A sign * suggested that for application by localized not broadcasted. Inorganic fertilizer in a form of N-P-K can be applied at rate of (5-6-10) $t \cdot ha^{-1}$ Entire P applied at planting to 1 week after planting (wap). NK split into twice, first application together with P, second application at (4 to 5) wap.

3.2. Sweet potato in the food security

Rice based is Indonesian food pattern. However, due to global climate change to increase rice production faces difficult problems. Community lives in rural remote or isolated areas such as in the hinterland of Papua that used of sweet potato as main staple. They are implementing the shifting agriculture can be described that their livelihood level still under subsistence[5]. Subsistence is a situation means for supporting life. It can be understood, living in rural remote areas where the infrastructure and information as well as communication access are very limited there is no choice for the community to live merely at subsistence style. Under subsistence living style, major activities, attention and time (> 60 %) are allocated to fulfil the basic human need, especially producing or gathering food for own consumption. In reality, subsistence living style is not merely undertaken by community lives in rural remote or isolated areas with very poor or limited infrastructure, but it is also experienced by poor community lives in slum areas of urban or suburb that are not able to spend or access the infrastructure available. The complex reason of poverty is the main cause of subsistence community lives in slum area. Implementation or regulation economic misuse marginalizes subsistence community under more difficult condition. People in slum areas are often assumed as lazy, workless or jobless, and as causal of low or poor economic growth. Indeed, there living style under poor condition was a consequence from the massy handling of development program that the main reason was to attain better living. In the future, commercialization is must be as a gate to share fairly the profit into equity as consequence to care farmers for sustaining high productivity under stability.

In the commercialization circumstance, including in the field under production level, efficient is the key point. Therefore, inorganic input is applied more and tends neglecting the role organic input due to laborious and time consuming. Since sweet potato in harvesting is moved out from the field, as the consequence the continuous planting will deplete the soil fertility. From the soil analysis indicated that the soil organic matter content of sweet potato field was very low, only around 1 % or even less. To sustain the high productivity balance soil management is required (Table 3). Better farmers' income from sweet potato farming is a key point to sustain high productivity with consequences to provide and improve organic matter in the soil. Although the production system under the huge frame of agribusiness is only one of sub-system, among the three others, however, in the long run sustainability is very important. Because, sustainability is not merely accomplished to the increase of productivity across the time, but it is simultaneously to be able to compromise the conflict need for the future generation. It means that sustainability in the broad sense should be able to conserve the natural resource from exploitation, degradation, and the lost of biodiversity. Sustainability of sweet potato production is not only caged into cultivation on pre-harvest aspects. But, it is related to the broad mission in holistic, integrative, and comprehensive approaches. Thus, it could not be simplified, reduced into partial action. Therefore, post harvest handling of sweet potato fresh root and its market are also the important agenda to be solved in the frame of sustainability. More over, if action research should be started from the end, to trigger the whole system of sweet potato to be more benefiting and

profiting farmers and consumers, so product and market development are urgently to be handled. Product and market development is a continuum, it alike of coin-side, if it is separated the tangible value is subsequently degraded. Market or product development is the logical articulation, because these two words could not be articulated together. Thus, the priority for sweet potato development in Indonesia is mainly laid on market and product development. Delaying to handle this problem is similar to postpone the poverty alleviation. Even more, due to farmers are not able to sell their sweet potato fresh root, and product development is not managed by farmers, so farmers will more suffer and trapped into poverty[6]. Poverty alleviation according to declaration of Vienna in 16th paragraph elucidated that this program was not only economic policy, but it was also related to social justice and welfare. Poverty problem is inter-related to many aspects, including less or no income, which further affect to dehumanization. This is controversial feature with the spirit of United Nation Organization who is strongly promoting about the human right[7]. Therefore, poverty alleviation in line with sustainable sweet potato production system is urgently tackled. In detail the wise policy could be made possible by considering the contribution of food crops into Gross Domestic Product. Cross subsidy, reallocation of budget to enhance farmers who grow crop other than rice should be given. Enhancing sustainable sweet potato production system is government task. Product and market development of sweet potato is an appropriate way out to be tackled in attempt to help farmers from puzzle circle, and departure from poverty condition into better welfare. Product development is mainly processed sweet potato fresh into intermediate or final goods in the agro-industrial enterprises. Product development is expected to broaden the utilization of sweet potato than did the previously. Market development could be generated by linking the farmers and consumers, and facilitating the transportation, fund, and in line regulation, for example by rethinking and rechecking about Raskin Program (inexpensive rice for the poor community), import of wheat and the other food crops. Maintaining traditional market and requesting supermarket to sell sweet potato fresh, intermediate and final products in rural, suburban and urban areas, supporting industrial enterprises with sweet potato used as the raw material seem as the breakthrough to broaden the domestic market of sweet potato, aside to develop export for foreign earning. Incentive or premium is required by farmers in order to sustain sweet potato production system in order to support continuously supply of the broaden demand for subsistence and commercialization. Despite farmers are never bothered with their own labour, but for fertilizer in a form of organic and/or inorganic need cash money. The use of external low input to sustain sweet potato production system is more recommended[8,9]. It means that to generate and activate the internal or in situ sweet potato production system under sustainable circumstances is low cost. On the other hand, the problem encountered with regard to biotic and a-biotic stresses are the challenge to sustain sweet potato at high productivity under stability (Table 4). If own farmer labour is calculated, starting from producing green forage for animal to produce dunks as organic fertilizer then harvesting fresh root and returning the waste back into the fields in attempts to balance the nutrient removed by sweet potato, therefore a farm gate price has to be appreciated. But, again the natural mandate of farmers is not only to produce the food and simultaneously conserve the natural resources; farmers should provide the adequate food with accessible price to the other poor people, of course, with low price. Farmers should also provide margin of price between retail and wholesale, thus there is an opportunity their sweet potato fresh root to be transported ad marketed by village traders.

It can be understood, when the farm gate price of sweet potato is so low, many traders are not encouraged to buy, because traditional market is difficult. Under such situation, processor for example sauce factories hunting a lot of benefit; due mainly to a huge margin between a lower price of raw material and a fix price for products. This fact is serious problem for the farmers, because they can not get cash income. Indeed government can help farmers by buying sweet potato fresh and distribute to the area which suffers from the hunger due to drought calamity. There is no strong of government to food diversification program. Unlike rice, government was able to determine floor price, and when the price fluctuated and tended to increase, market operation subsequently done to control the price. For sweet potato, there is no policy implied as the action of Act No 18 year of 2012 or its regulation. Therefore, food security is still dominated into only rice; food diversification is merely stopped in discourses or master plan without any implementation. Recent fact indicated in West and East Nusa Tenggara as well as in Kalimantan, several infants died due to hunger calamity. Malnutrition in two faces of Kwasioqor and Marasmus due to the lack of carbohydrate and protein intake is serious problem for the poor or subsistence community. Therefore, sweet potato that has flexibility to be harvested under various ages is recommendable for fulfilling and supporting food security[10,11]. Based on the various experiences, in commercialization of sweet potato require the regulation to balance between supply and demand. Thus, there is no excessive supply due to many farmers grow sweet potato that consequence to farmers unbeneficial; or lack of supply that promotes to high price so processors difficult to enjoy a margin.

Reference[12] suggested that government has to establish the board for maintaining price of agriculture produces, especially related to food security program. Regulation has to be undertaken between farmers, traders and processor, role of government as referee or to facilitate stakeholders to share risk and profit. By incorporating the ethical value with rationale and realistic in the regulation of sweet potato commercialization, risk is not loaded merely to farmers; but also profit for better income is also the right of farmers. Sacrificing farmers on the name of development must be terminated. Poor farmers who grow sweet potato are able to help poor community in rural, slum of urban and sub-urban areas (Table 4). In future, commercialization in must be as a gate to share fairly the profit into equity as consequence to care farmers for sustaining high productivity under stability.

Table 4. Contribution of sweet potato to poor community lives under subsistence due to marginalize by the modern life style.

Items	Subsistence community in	
	Rural remote or isolated areas*	Slum in urban or suburb areas**
Infrastructure	Lack or poor	Available but not able to access
House condition	Very poor	Very poor
Environment condition	Good	Very poor
Livelihood	Farming based on shifting agriculture	Informal job, often workless
Income	Very poor, cash income uncertainty	Poor, cash income irregular
Food	Available in the field by piecemeal harvest, or hunting and gathering from forest area	Not always available at household, must spend cash for food
Sweet potato contribution	Very important as staple food for 3 meals a day, root eaten as source of carbohydrate, vitamin and minerals, young leaves as vegetable. Sweet potato root consumed (3 to 6) kg/capita/day	Significant role as supplemental food when the price of rice is expensive.

Note: * Based on several observations undertaken by regular visits to the hinterlands of Papua from 1995 to 2003.
** Observations at slum areas of Malang, Surabaya and Jakarta.

Under subsistence circumstances, sweet potato is an excellent food source. Aside, as a source of carbohydrate there is vitamin A and C as well as minerals. The lack of protein content could be supplied from another food source either from plants or animals[13,14] indicated that the poor community in slum areas of Jakarta had a way to fulfil their food required from sweet potato and other root crops when the price of rice increased. Similar phenomenon was elucidated by[15] that during the beginning of economic and food crisis, the role of root crops increased, unfortunately due to there was no anticipation previously, thus the price was also increase, but it at a standstill could be covered by poor community. Based on the lesson learnt from food and economic crisis, agriculture have not to be weak, it must strong to be able feeding the people[16]. For the community living in eastern part of Indonesia, particularly in the hinterlands of Papua, sweet potato had been used since a long time ago up to now as a staple food. The topography of the hinterland of Papua mostly are mountainous with very steep slope as well as undulating area, which is reflecting a fragile condition from the man made. Therefore, in order to maintain food sufficiency for the community in this area needs an appropriate approach to compromise the conflict requirement for short and long-term. The fragile of edapo-climatic conditions should be considered as a challenge and opportunity to attain food security with ecologically sounded. Relatively less of natural enemies of sweet potato, the longer range of harvesting periods, and its adaptability to be cultivated under agro-forestry system are the potential belong to this crop preferred by the community in the highlands of Papua, as the staple food. Preparation of sweet potato for human food in these areas by the way so called as ‘bakar batu’ or hot stone. Principally in hot stone method, sweet potato and other rootcrops as well as vegetables are prepared by put the hot stone in a form of mound. The procedure of hot stone method such as follow: i) To burn the stone into fire of wood; ii) When the colour of stone to be red as indicator very hot, stone taken out and put around of wrapped vegetable and sweet potato in a small pit in the soil. The size of hole in the ground (ditch) depends on the amount of sweet potato or vegetables prepared or number of people involved for banquet. Hot stone food preparation is not ecologically friendly, because needs huge of wood. In the high altitude of Papua that the growth of wood is slow, hot stone has a detrimental effect to the sustainability of forest. People are not only pick the dead branch of tree, but also cut living tree then after dry in couple of days they come to pick for food preparation. Therefore, the tradition of hot stone method for food preparation needs to be

revised or improved, because threatening the high altitude agro-ecological zones of Papua. To accomplish food security for the community in the highlands of Papua, productivity and quality of sweet potato needs to be improved, and on the other hand cultivation technology with ecologically friendly should be developed in attempts to provide a better environment for future generations. Under the climate change, as such drought disaster sweet potato harvest and yield as well as quality to be worse, so famine calamity is commonly as the further consequences. Food aid program in a form of rice distribution in the long run is not an appropriate answer to combat against famine calamity in the hinterlands of Papua. Because, the basic of food habit as well as motivation of the community to sustain the productivity of sweet potato as the main daily meal are threatened. To sustain the production system of sweet potato under such circumstances, in-situ input management seems effective and efficient to be developed. Shifting agriculture with its image is less intensive should be changed by intensive farming. Intercropping to provide more food and income has also a positive respond from the community[17] elucidated that incorporation of maize, beans as well as taro into sweet potato based intercropping system by better crop arrangement in the high altitude of Papua was able to secure food under the fragile of agro-ecological zones.

4. Conclusion

Based on the explanation of results and elaboration as well as discussion, the following conclusion can be presented as below:

- Sweet potato as relatively nutritious due to its carbohydrate, vitamin A and C as well as mineral is an appropriate source of food for people in subsistence community. The wide adaptability to grow under various environments, less pest and disease, responsive to inputs and wider harvesting periods has an effect on its popularity to be chosen by subsistence peasant in rural remote areas. The sweet and excellent taste, longer storability with very simple preparation is also the reason that sweet potato as suitable supplemental food for poor people in urban and suburb areas.
- Commercialization of sweet potato has to be able to facilitate especially farmers, thus farmers are not merely sacrificed to take risk. The principle to nurture the commercialization by care, share fairly between stakeholders involved is a key to sustain the system. To foster the commercialization in line with humanity, an ethical value has to be incorporated into the formal regulation or the Act.
- Sustainable sweet potato production system is strongly required to meet the greater demand for food security as well as bio-ethanol for beverage and fuel. To build the sustainability by sharing and implementing know how in the form of Participatory Technology Development through Farmer Field School model.

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